CLAIMS

1. Cable (1) for use in a predetermined voltage class, said cable comprising:
   - a conductor (2);
   - an insulating layer (4) surrounding said conductor (2), and
   - a protective element (20) around said insulating layer (4) having a thickness and mechanical properties selected to provide a predetermined impact resistance capability, said protective element (20) comprising at least one expanded polymeric layer (22),

   characterized in that:
   - said insulating layer thickness is such as to provide a voltage gradient on the outer surface of the cable insulating layer not smaller than 1.0 kV/mm, and
   - said protective element thickness is sufficient to prevent a detectable insulating layer damage upon impact of at least 25 J energy.
2. Cable (1) according to Claim 1, wherein said predetermined voltage class is not higher than 10 kV.
3. Cable (1) according to Claim 1, wherein said voltage gradient is not smaller than 2.5 kV/mm and said impact is of at least 50 J energy.
4. Cable (1) according to Claim 3, wherein said predetermined voltage class is comprised between 10 kV and 60 kV.
5. Cable (1) according to Claim 1, wherein said voltage gradient is not smaller than 2.5 kV/mm and said impact is of at least 70 J energy.
6. Cable (1) according to Claim 5, wherein said predetermined voltage class is higher than 60 kV.
7. Cable (1) according to Claim 1, wherein said insulating layer thickness is at least 20% smaller than the insulating layer thickness provided for in IEC Standard 60502-2 for the corresponding voltage class.
8. Cable (1) according to Claim 1, wherein said predetermined voltage class is 10KV and said insulating layer thickness is not higher than 2.5

mm.

9. Cable (1) according to Claim 1, wherein said predetermined voltage class is 20KV and said insulating layer thickness is not higher than 4 mm.

10. Cable (1) according to Claim 1, wherein said predetermined voltage class is 30KV and said insulating layer thickness is not higher than 5.5 mm.

11. Cable (1) according to Claim 1, wherein said conductor is a solid rod.

12. Cable (1) according to Claim 1, further including an electric shield (6) surrounding said insulating layer (4), said electric shield comprising a metal sheet shaped in tubular form.

13. Cable (1) according to Claim 1, wherein said insulating layer thickness is selected so that the electrical stress within the insulating layer when the cable is operated at a nominal voltage corresponding to said predetermined voltage class ranges among values comprised between 2.5 and 18 kV/mm.

14. Cable (1) according to Claim 1, wherein said protective element (20) is placed in a position radially external to said insulating layer (4).

15. Cable (1) according to Claim 1, wherein the degree of expansion of said expanded polymeric layer (22) is between 0.35 and 0.7

16. Cable (1) according to Claim 15, wherein said degree of expansion is between 0.4 and 0.6.

17. Cable (1) according to Claim 1, wherein said expanded polymeric layer (22) has a thickness between 1 and 5 mm.

18. Cable (1) according to Claim 1, wherein the expandable polymeric material of said expanded polymeric layer (22) is selected from polyolefin polymers or copolymers based on ethylene and/or propylene.

19. Cable (1) according to Claim 18, wherein said expandable polymeric material is selected from:

a) ethylene copolymers with an ethylenically unsaturated ester in which the quantity of unsaturated ester is comprised between 5% and 80% by weight,

b) elastomeric copolymers of ethylene with at least one C_3-C_{12} α-olefin, and optionally a diene, having the following composition: 35%-90% as moles of ethylene, 10%-65% as moles of α-olefin, 0%-10% as moles of diene,

c) copolymers of ethylene with at least one C_4-C_{12} α-olefin, and optionally a diene, having a density between 0.86 and 0.90 g/cm^3,

d) polypropylene modified with ethylene/C_3-C_{12} α-olefin copolymers where the ratio by weight between polypropylene and the ethylene/C_3-C_{12} α-olefin copolymer is comprised between 90/10 and 30/70.

20. Cable (1) according to Claim 1, wherein said protective element (20) further includes at least one non-expanded polymeric layer (21, 23) coupled with said expanded polymeric layer (22).

21. Cable (1) according to Claim 20, wherein said at least one non-expanded polymeric layer (21, 23) has a thickness in the range of 0.2 to 1 mm.

22. Cable (1) according to Claim 20, wherein said at least one non-expanded polymeric layer (21, 23) is made of a polyolefin material.

23. Cable (1) according to Claim 20, wherein said protective element (20) comprises a first non-expanded polymeric layer (23) in a position radially external to said expanded polymeric layer (22).

24. Cable (1) according to Claim 20, wherein said protective element (20) comprises a second non-expanded polymeric layer (21) in a position radially internal to said expanded polymeric layer (22).

25. Cable (1) according to Claim 1, comprising a further expanded polymeric layer (8) in a position radially internal to said protective element (20).

26. Cable (1) according to Claim 25, wherein said further expanded polymeric layer (8) is in a position radially external to said insulating layer (4).

27. Cable (1) according to Claim 25, wherein said further expanded polymeric layer (8) is semiconductive.

28. Cable (1) according to Claim 1, wherein said further expanded polymeric

layer (8) is water swellable.

29. Cable (1) according to Claim 1, wherein said conductor (2) is a metal rod.

30. Cable (1) according to Claim 1, wherein said insulating layer (4) is made of a non-crosslinked base polymeric material.

31. Cable (1) according to Claim 1, wherein said predetermined voltage class belongs to a medium or high voltage range.

32. A cable (1) for use in a predetermined voltage class, said cable comprising:

- a conductor (2);
- an insulating layer (4) surrounding said conductor (2), and
- a protective element (20) around said insulating layer (4) comprising at least one expanded polymeric layer (22),

characterized in that the protective element thickness has a value smaller than 7.5 mm for a conductor cross-sectional area greater than 50 mm^2 and a value greater than 8.5 mm for a conductor cross-sectional area smaller than or equal to 50 mm^2.

33. A cable (1) according to Claim 32, wherein said predetermined voltage class is higher than 60 kV and said insulating layer is not detectably damaged upon impact of an energy of at least 70 J.

34. A cable (1) according to Claim 32, wherein said predetermined voltage class is not higher than 60 kV and said insulating layer is not detectably damaged upon impact of an energy of at least 50 J.

35. A cable (1) according to Claim 32, wherein said predetermined voltage class is not higher than 10 kV and said insulating layer is not detectably damaged upon impact of an energy of at least 25 J.

36. A group of cables selected for a predetermined voltage class and having different conductor cross-sectional areas, each cable comprising:

- a conductor (2);
- an insulating layer (4) surrounding said conductor (2), and
- a protective element (20) around said insulating layer (4) comprising at least one expanded polymeric layer (22),

wherein the thickness of said protective element (20) is in inverse relationship with the conductor cross-sectional area.

37. A group of cables according to Claim 36, wherein said protective element (20) further includes at least one non-expanded polymeric layer (21, 23) coupled with said at least one expanded polymeric layer (22).

38. A group of cables according to Claim 36, wherein each cable comprises a further expanded polymeric layer (8) in a position radially internal to said protective element (20).

39. A group of cables according to Claim 37, wherein said expanded polymeric layer (22) has constant thickness and one non-expanded polymeric layer (23) of said non-expanded polymeric layers (21, 23) increases in thickness in inverse relationship with the conductor cross-sectional area.

40. Method for designing a cable (1) comprising a conductor (2), an insulating layer (4) surrounding said conductor (2) and a protective element (20) surrounding said conductor (2), said protective element (20) including at least one polymeric expanded layer (22), said method comprising the steps of:

- selecting a conductor cross-sectional area;
- determining the thickness for said insulating layer compatible with safe operation in a predetermined voltage class on said selected conductor cross-sectional area in correspondence of one of a number of predetermined electrical limit conditions;
- selecting the maximum insulating layer thickness among those determined in said number of predetermined electrical limit conditions;
- determining a thickness of said protective element so that said insulating layer is not detectably damaged upon an impact is caused on the cable of an energy of at least 50 J, and
- using said selected insulating layer and said determined protective element thickness in the design of a cable for said predetermined voltage class and selected conductor cross-sectional area.

41. Method according to Claim 40, wherein said step of determining a thickness of said protective element (20) comprises the step of determining a thickness of said expanded polymeric layer (22).

42. Method according to Claim 40, wherein said step of determining a thickness of said protective element (20) comprises the step of selecting a thickness of said expanded polymeric layer (22) and determining a thickness of at least one non-expanded polymeric layer (21, 23) associated with said expanded polymeric layer (22), said protective element (20) comprising said at least one non-expanded polymeric layer (21, 23).

43. Method according to Claim 42, wherein said step of determining a thickness of at least one non-expanded polymeric layer comprises the step of correlating in inverse relationship the thickness of said at least one non-expanded polymeric layer with the conductor cross-sectional area.

44. Method according to Claim 42, in which said predetermined electrical limit conditions include the electric gradient at the outer surface of the insulating layer.